Chapter 4

Results and Discussion

4 Results and Discussion

4.1 Introduction

Processing all kinds of warp threads on a single warping system offers many advantages over two different warping systems. To process all kinds of threads it is necessary to design a new system. As mentioned in chapter 3, a new beam has been designed for unifying two systems of warping. Various parts of the newly designed beam have been narrated with diagrams in the previous chapter. In this chapter the parts will be looked at with 3D printed version and actual measurements and calculations will be carried out. In initial part of this chapter 3D printed parts are described with motion simulation. In the later part actual dimensions used in the design are described with calculations.

4.2 3D Protoype

FDM based 3D printer with model Dimension 1200es was used for generating prototype parts. The machine has capacity of making parts with maximum dimension of 254 x 254 x 305 mm (10 x 10 x 12 in). So it is necessary to scale down all parts. The scale down of approximately 1:10 for the design was selected which will provide maximum utilization of the machine capacity. 3D printing is prototyping and works with hard ABSplus plastic material. So the parts printed will have enough strength for motion simulation and will have real life look. Currently many regular parts in various industries are directly manufactured through 3D printing technology.

There were two options available while 3D printing. The first option is that of making the entire assembly as one piece and later on removing the support material. This option was tried but due to many gaps in the small size teeth it was not possible to remove the support material fully.

The other option was to print individual parts and then make the assembly. More precision is required while following this route. Also some modifications have to be made so that all parts can be assembled without causing damage. The FDM technology of 3D printing leaves very fine serrations on all printed parts. These marks are required to be polished with a very fine polish paper. Extreme care is required while polishing due to reduced size of all parts especially where the teeth are made.

In the current experiment second option was found to be successful. It is worthwhile to note here that all these modifications are not required while manufacturing actual beam with full dimensions.

4.2.1 Parts – First Attempt

There were three unsuccessful trials before the first working prototype version can be made. As mentioned above, one major problem with 3D printing is that of removal of support material particularly if the design involves intricate design with very small parts. Due to scaling down the teeth size became very small and the same used to break or wear out quickly. So minor modifications were done wherever required to generate the parts and to have required motion. Also the number of separator plates were reduced to 4 only.

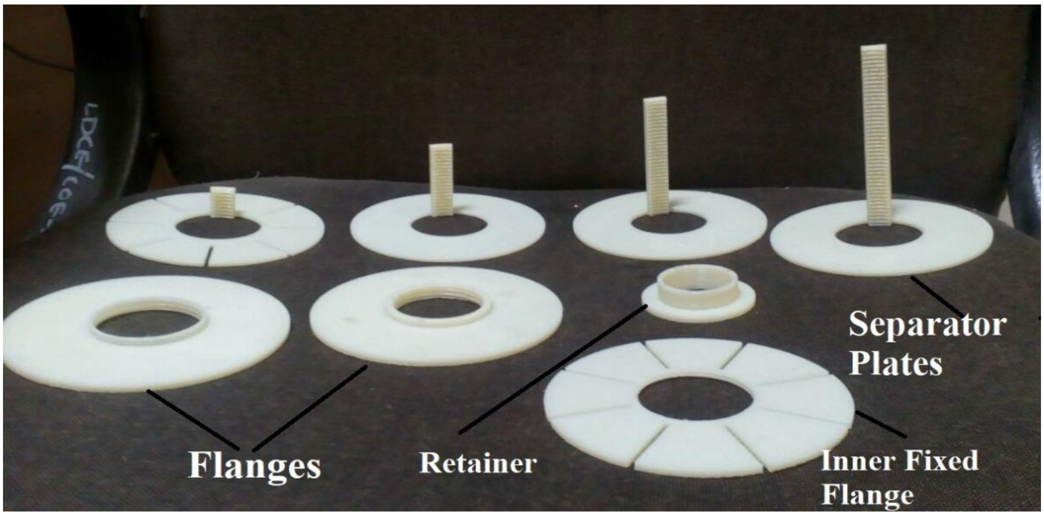


Fig 4.1 Flanges, Inner fixed flange, Retainer and Separator Plates

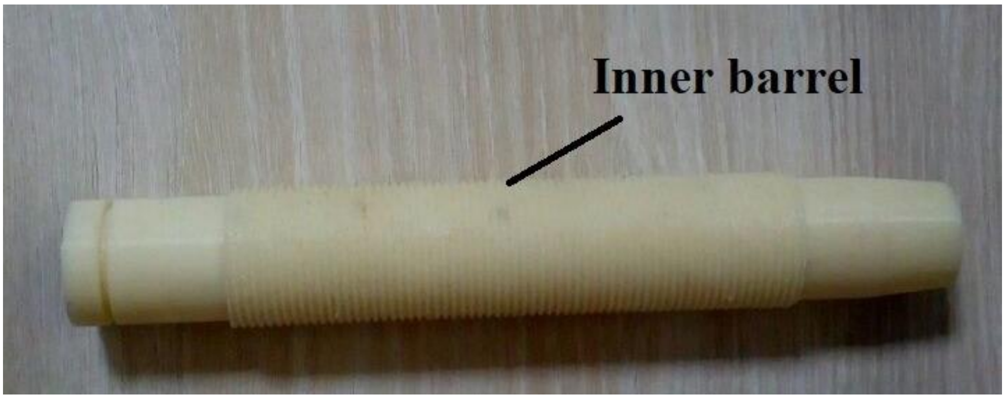


Fig 4.2 Inner Barrel

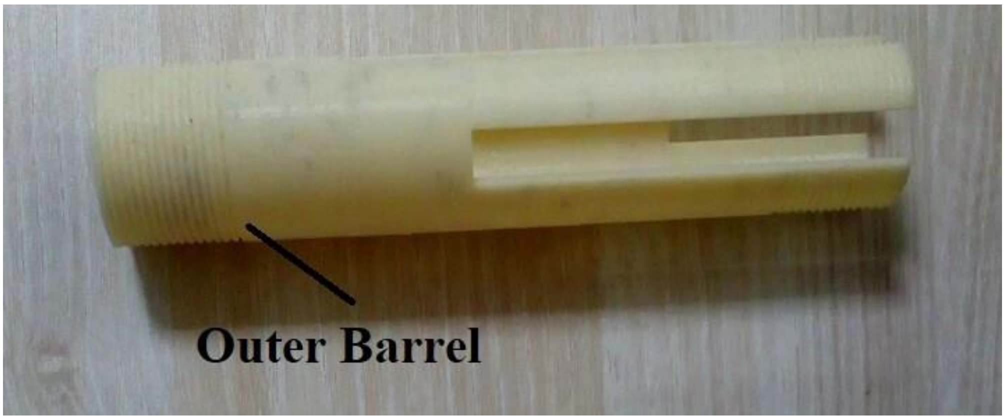


Fig 4.3 Outer Barrel

Slight change in the design of retainer block was also made to suit the current prototype. The ratio of number of teeth on inner barrel to the number of teeth on strip mounted on separator plate was kept as 1:1 which means that one revolution of inner barrel will provide one tooth equivalent lateral movement to the teeth. Figures 4.1 shows separator plates, flanges, inner fixed flange and retainer block.

Figure 4.2 shows inner barrel. One end of the inner barrel is slightly tapered to accommodate the retainer block. The other end of inner barrel has a small groove to fix the circlip. These elements of the design have been provided to see the working of the prototype only. Actual design has already been discussed in the previous chapter. Figure 4.3 shows outer barrel with slots made to accommodate strips provided on the separator plate. The length of the slot will be as per the requirement of the respective strip of the separator plate.

4.2.2 Motion Simulation of Prototype – First Attempt

After generating all parts, an assembly was made. Due care is required to be taken while joining each part with the other. Though the material had enough strength, but due to reduction in size some portions became very small, and so they were fragile at some portions.

The whole assembly is as shown in figure 4.4. This assembly is very close replica of the actual version of the beam. At the same time the main concept of the whole design can be clearly understood.

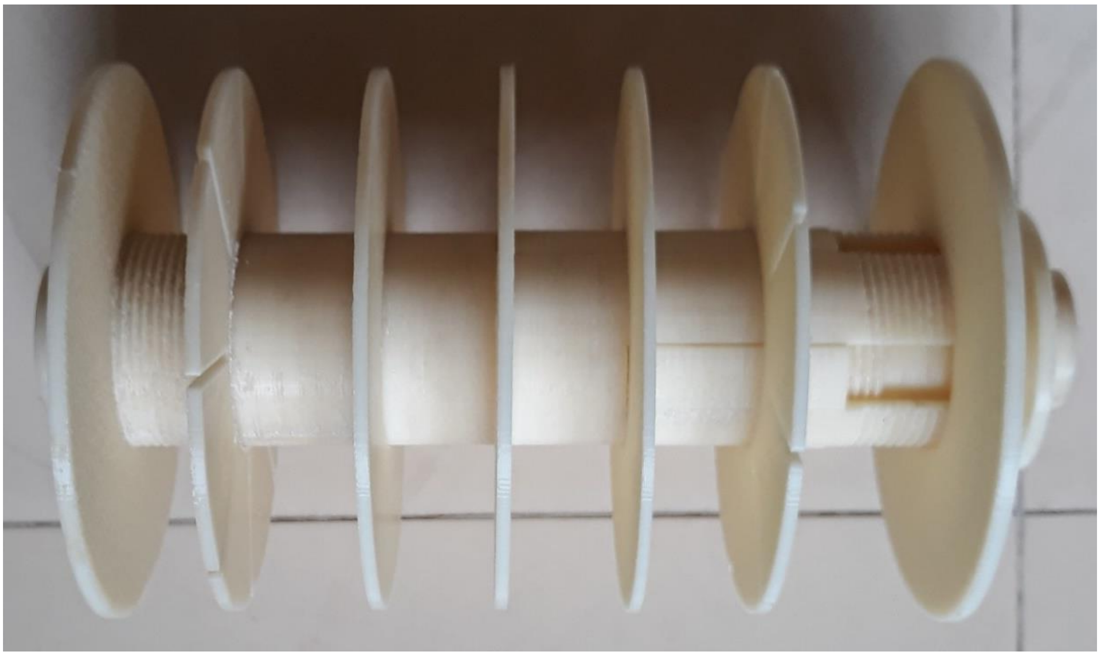


Fig 4.4 Assembly

Following steps were undertaken to assemble and carry out width adjustment of the whole design:

1. While assembling, the inner barrel was inserted in to the outer barrel.

2. From the left hand side of the barrel, inner fixed flange was inserted and firmly fixed with the outer barrel surface.
3. After that left hand side barrel is inserted by rotating over the teeth.
4. Separator plates were inserted from right hand side of the barrel one by one. They are to be inserted as per their respective number. The plate with the longest strip will be inserted first and with the smallest strip will be inserted last.
5. Now the right hand side flange will be inserted.
6. The testing of the mechanism was done by firstly rotating both side flanges. As mentioned earlier, the flange adjustment is required to adjust the width of the first and the last sections of the beam which include selvedge threads.
7. Now the inner barrel was rotated. By doing this the strips will move laterally by an equal distance. The inner barrel can be rotated in both the directions to facilitate the movement of plates inside or outside. This will enable the adjustment of width of all main sections at an equal value.

   Here the error in the model emerged and it was realized that all separator plates move simultaneously by equal distance. The requirement of the movement will be that there is an equal distance between successive separator plates. With the current version the distance between all separator plates remained at the original value. And all separator plates moved on either side together. The error generated because all plates have been mounted on the inner barrel having uniform teeth structure. Also the ratio of teeth on the strip to the teeth on inner barrel was kept at 1:1. This was a moment for the newer thought for the solution.
8. After carrying out the width adjustment of all sections, the whole system is to be locked. This is done by placing a retainer block at the end of the inner barrel. As mentioned, the design of the retainer block

was modified slightly for 3D printing purpose only. The actual design has been mentioned in chapter 3.

4.2.3 Parts – Third Attempt

As mentioned in section 3.5.3, another attempt was made to resolve the problem discussed above. The prototype was manufactured with the help of same 3D printer. Again the entire design was made by printing parts separately. The inner barrel involved main changes so it was printed totally new. And separator plates were printed again too as there were some minor changes in to the design. The design of the inner barrel is shown at figure 4.5.

As seen in the figure 4.5, the pitch of the teeth made on to the inner barrel is in the increasing order. The pitch has been designed with a value of almost 0 to 20 mm over a length of 140 mm. Each successive tooth of the barrel has an incremental value of the pitch. The 3D printed prototype is shown at figure 4.6.

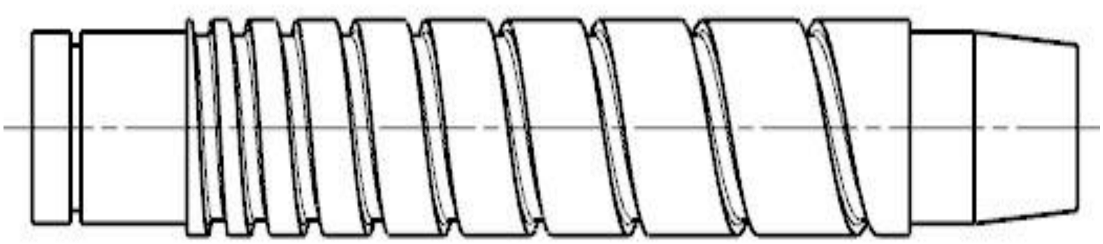


Fig 4.5 Design of the Inner Barrel Third Attempt

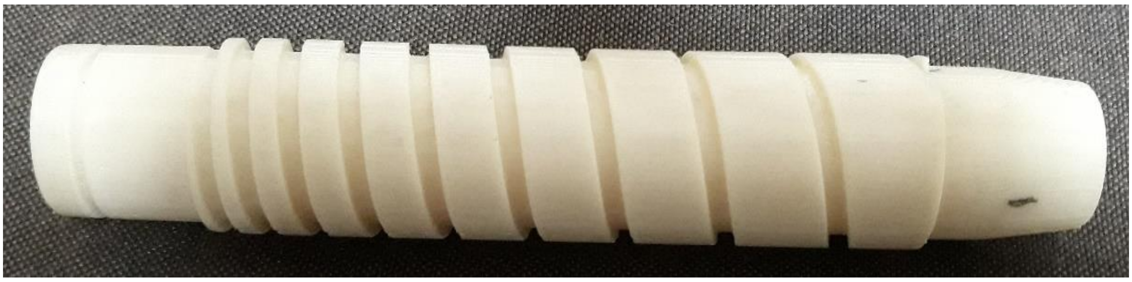


Fig 4.6 3D printed Prototype of Inner Barrel - Third Attempt

The figure 4.7 shows the prototype design of the separator plate and magnified view of the pin. The overall design of the plate has been retained as that of the first version. The change is in to the inner side of the strip. In earlier version, the strips had toothed structure on the underside whereas in this version there is a pin and no toothed structure. The first separator plate will be positioned at a pitch of 3 mm as the pin on the strip of the separator plate is located at that distance. The second plate can be kept at any position along the length while aligning with the slot made for the strip on the outer barrel. Similarly later on plates can be positioned as per the desired location.

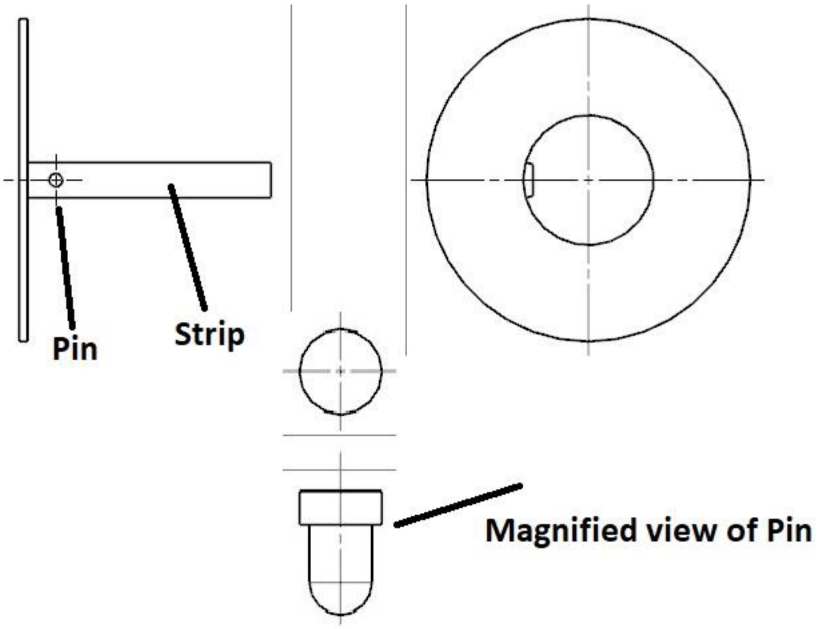


Fig 4.7 Separator Plate and Pin - Third Attempt

4.2.4 Motion Simulation of Prototype – Third Attempt

After generating all parts, an assembly was made. The whole assembly design is as shown in figure 4.8. Fully assembled prototype is as shown in figure 4.9. This assembly is very close replica of the actual version of the beam. At the same time the main concept of the whole design can be clearly understood.

The steps required to be undertaken to assemble and carry out width adjustment of the whole design were same as before. The prototype can be worked manually.

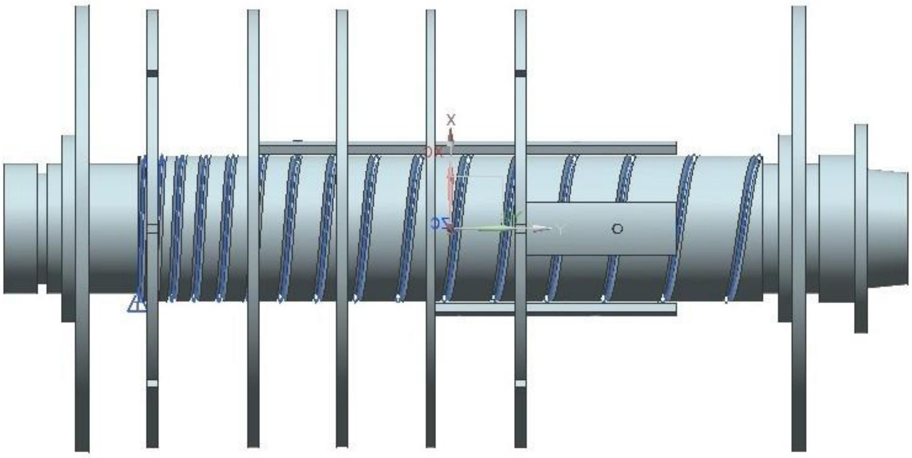
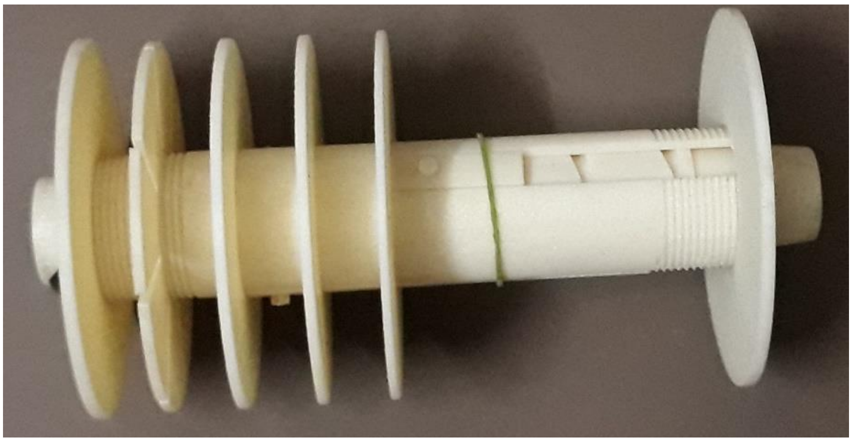


Fig 4.8 Fully assembled view of the design – Third Attempt



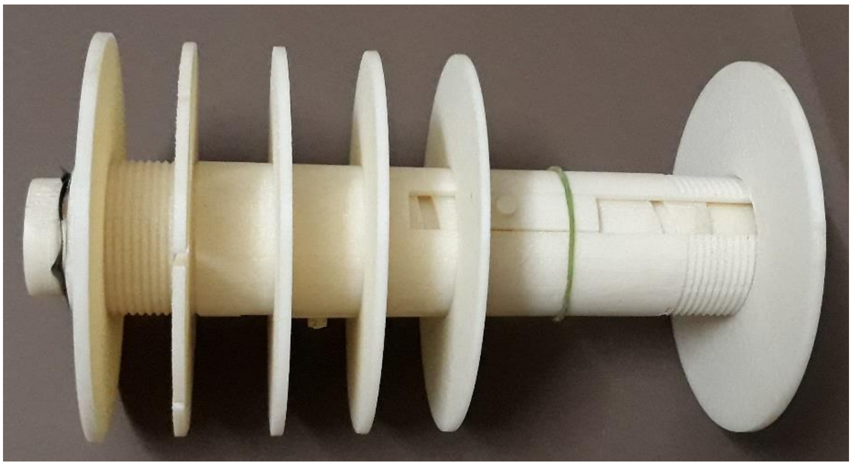


Fig 4.9 Fully Assembled Prototype – Third Attempt

After inserting the inner barrel, one end having the groove will have a circlip fixed which will prevent the horizontal movement of the barrel. It is now possible to rotate the inner barrel manually both ways i.e. clockwise and anticlockwise. This will cause horizontal shifting of the separator plates. As the pitch on the barrel has been so designed that the plates will have an incremental movement. In the prototype three separator plates have been provided and there is one inner fixed flange.

The distance between separator plates 1 to 2 and 2 to 3 will be adjusted by rotating inner barrel in either direction. The distance between inner fixed flange and the first plate will be adjusted by rotating fixed flange. Whereas the width for first and the last section will be adjusted by rotating main flanges in either direction. By watching the working of the prototype it is evident that it can be replicated for the full beam as well.

4.3 Measurements

As mentioned in earlier section, the beam used in the current concept is the one used on an air jet loom of RIFA make. Measurements wherever necessary were used of that beam. This has been done keeping in mind that the beam can be used directly on the loom. Alternatively warper’s beam can be used if sizing is required to be carried out. The whole concept of the design is meant to be used on direct warping system. Once again it is worth to mention here that the designed beam is to be used on a direct warping machine when it is desired to warp multi-color threads. The creel set out will be done as it is done for any type of sectional warping machine. Normal warper’s beam will be used if one wants to produce mono color warp.

The measurements shown here are for a particular example only. The dimensions can be changed as per the requirements. Suitable changes can be made in the design of inner shaft, separator plates etc. In the current design it has been assumed that there will be 10 - 12 sections in total which means that there will be

2 less sections containing ends requiring an equal width adjustments considering that selvedge threads are extra and not part of the body threads.

Following table shows various measurements used during the design of the full beam. The values are for the second and the third attempt only.

Value	Second Attempt	Third Attempt
	(All values in mm)	
Total width of the beam	2100	2100
Width for Warp (maximum)	1900	1900
Outer Barrel		
Diameter of outer barrel	182	182
Length of outer barrel	2100	2100
Circumference of outer barrel	571.5	571.5
No. of slots	10	10
Width of slots	20	20
Length of slot no. 1	1500	1500
Length of the last slot	As per requirement	As per requirement
Inner Barrel		
Diameter of inner barrel	152	152
Length of inner barrel	2100	2100
Length over which threading done	1600	1600
Separator Plates		
Diameter of separator plates	800	800
Thickness of separator plates	3	3
Distance over which teeth have been made	20	----
Size of the pin	----	5 x 15
Diameter of Main flanges	900	900
Thickness of Main Flanges	30	30

Table 4.1 Measurements of full size beam

4.3.1 Measurements for Second Attempt

In the second attempt, the inner barrel has been designed having sections with varying pitch value. This means that the successive sections will have an increasing pitch value so as to maintain the same width of all sections other than the first and the last one. Measurement tables have been prepared considering the pitch value of 1 mm for first section, different section width and for different values of ends per inch. As shown in table 4.2, EPI values have been selected from 40 to 140 in a group of 10. The table 4.2 shows the initial section width values ranging from 50 mm to 69 mm considering that there will be 20 sections made on to the inner barrel. The table shows the number of ends which can be accommodated in first section with reference to a particular section width for a given value of ends per inch. Same number of threads will be there in remaining sections. Again it will be repeated here that an equal number of separator plates have to be designed with matching values of pitch.

Section Width (mm) ↓	Ends per Inch										
	40	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**
50	79	98	118	138	157	177	197	217	236	256	276
51	80	100	120	141	161	181	201	221	241	261	281
52	82	102	123	143	164	184	205	225	246	266	287
53	83	104	125	146	167	188	209	230	250	271	292
54	85	106	128	149	170	191	213	234	255	276	298
55	87	108	130	152	173	195	217	238	260	281	303
56	88	110	132	154	176	198	220	243	265	287	309
57	90	112	135	157	180	202	224	247	269	292	314
58	91	114	137	160	183	206	228	251	274	297	320
59	93	116	139	163	186	209	232	256	279	302	325
60	94	118	142	165	189	213	236	260	283	307	331
61	96	120	144	168	192	216	240	264	288	312	336
62	98	122	146	171	195	220	244	269	293	317	342
63	99	124	149	174	198	223	248	273	298	322	347
64	101	126	151	176	202	227	252	277	302	328	353
65	102	128	154	179	205	230	256	281	307	333	358
66	104	130	156	182	208	234	260	286	312	338	364
67	106	132	158	185	211	237	264	290	317	343	369
68	107	134	161	187	214	241	268	294	321	348	375
69	109	136	163	190	217	244	272	299	326	353	380

Table 4.2 Number of maximum ends with section width of 50 to 69 mm

As can be seen from the table that maximum ends are with a value of 69 mm section width and with 140 ends per inch. Similar tables for different ranges of section widths have been prepared and are presented at table numbers 4.3 to 4.7.

Section Width (mm)	Ends per Inch										
	40	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**
100	157	197	236	276	315	354	394	433	472	512	551
101	159	199	239	278	318	358	398	437	477	517	557
102	161	201	241	281	321	361	402	442	482	522	562
103	162	203	243	284	324	365	406	446	487	527	568
104	164	205	246	287	328	369	409	450	491	532	573
105	165	207	248	289	331	372	413	455	496	537	579
106	167	209	250	292	334	376	417	459	501	543	584
107	169	211	253	295	337	379	421	463	506	548	590
108	170	213	255	298	340	383	425	468	510	553	595
109	172	215	257	300	343	386	429	472	515	558	601
110	173	217	260	303	346	390	433	476	520	563	606
111	175	219	262	306	350	393	437	481	524	568	612
112	176	220	265	309	353	397	441	485	529	573	617
113	178	222	267	311	356	400	445	489	534	578	623
114	180	224	269	314	359	404	449	494	539	583	628
115	181	226	272	317	362	407	453	498	543	589	634
116	183	228	274	320	365	411	457	502	548	594	639
117	184	230	276	322	369	415	461	507	553	599	645
118	186	232	279	325	372	418	465	511	557	604	650
119	187	234	281	328	375	422	469	515	562	609	656

Table 4.3 Number of maximum ends with section width of 100 to 119 mm

Section Width (mm) ↓	Ends per Inch										
	40	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**
130	205	256	307	358	409	461	512	563	614	665	717
131	206	258	309	361	413	464	516	567	619	670	722
132	208	260	312	364	416	468	520	572	624	676	728
133	209	262	314	367	419	471	524	576	628	681	733
134	211	264	317	369	422	475	528	580	633	686	739
135	213	266	319	372	425	478	531	585	638	691	744
136	214	268	321	375	428	482	535	589	643	696	750
137	216	270	324	378	431	485	539	593	647	701	755
138	217	272	326	380	435	489	543	598	652	706	761
139	219	274	328	383	438	493	547	602	657	711	766
140	220	276	331	386	441	496	551	606	661	717	772
141	222	278	333	389	444	500	555	611	666	722	777
142	224	280	335	391	447	503	559	615	671	727	783
143	225	281	338	394	450	507	563	619	676	732	788
144	227	283	340	397	454	510	567	624	680	737	794

Table 4.4 Number of maximum ends with section width of 130 to 144 mm

Section Width (mm) ↓	Ends per Inch										
	40	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**
200	315	394	472	551	630	709	787	866	945	1024	1102
201	317	396	475	554	633	712	791	870	950	1029	1108
202	318	398	477	557	636	716	795	875	954	1034	1113
203	320	400	480	559	639	719	799	879	959	1039	1119
204	321	402	482	562	643	723	803	883	964	1044	1124
205	323	404	484	565	646	726	807	888	969	1049	1130
206	324	406	487	568	649	730	811	892	973	1054	1135
207	326	407	489	570	652	733	815	896	978	1059	1141
208	328	409	491	573	655	737	819	901	983	1065	1146
209	329	411	494	576	658	741	823	905	987	1070	1152

Table 4.5 Number of maximum ends with section width of 200 to 209 mm

Section Width (mm) ↓	Ends per Inch										
	40	50	60	70	80	90	100	110	120	130	140
300	472	591	709	827	945	1063	1181	1299	1417	1535	1654
301	474	593	711	830	948	1067	1185	1304	1422	1541	1659
302	476	594	713	832	951	1070	1189	1308	1427	1546	1665
303	477	596	716	835	954	1074	1193	1312	1431	1551	1670
304	479	598	718	838	957	1077	1197	1317	1436	1556	1676
305	480	600	720	841	961	1081	1201	1321	1441	1561	1681
306	482	602	723	843	964	1084	1205	1325	1446	1566	1687
307	483	604	725	846	967	1088	1209	1330	1450	1571	1692
308	485	606	728	849	970	1091	1213	1334	1455	1576	1698
309	487	608	730	852	973	1095	1217	1338	1460	1581	1703

Table 4.6 Number of maximum ends with section width of 300 to 309 mm

Section Width (mm) ↓	Ends per Inch										
	40	50	60	70	80	90	100	110	120	130	140
350	551	689	827	965	1102	1240	1378	1516	1654	1791	1929
351	553	691	829	967	1106	1244	1382	1520	1658	1796	1935
352	554	693	831	970	1109	1247	1386	1524	1663	1802	1940
353	556	695	834	973	1112	1251	1390	1529	1668	1807	1946
354	557	697	836	976	1115	1254	1394	1533	1672	1812	1951
355	559	699	839	978	1118	1258	1398	1537	1677	1817	1957
356	561	701	841	981	1121	1261	1402	1542	1682	1822	1962
357	562	703	843	984	1124	1265	1406	1546	1687	1827	1968
358	564	705	846	987	1128	1269	1409	1550	1691	1832	1973
359	565	707	848	989	1131	1272	1413	1555	1696	1837	1979

Table 4.7 Number of maximum ends with section width of 350 to 359 mm

As seen in these tables that one can have a particular combination of section width for a given situation. The design covers all types of combinations which one encounters in actual set up. If desired one may have a set of different beams suiting varied needs. The maximum number of ends which can be taken in a section are ranging from nearly 80 to 2000. This will satisfy requirements of most of the apparel fabrics.

4.3.2 Calculations for Second Attempt

In this section some examples of actual situations will be taken up and the calculations of the same will be done. The attempt will be checked with reference to the examples and will be verified whether the designed system is capable of working. As mentioned earlier, the examples of patterned warp will be taken up with two different situations.

Example 1:

Following are the details of the warp yarn to be processed.

- *Ends per inch : 120*
- *Width : 1422.4 mm (56 inches) including selvedges*
- *Selvedge : 120 ends per inch, 0.5" on each side, white color*
- *Warp pattern repeat : 104 ends, 4 colors*
- *Total ends : 6720 (6600 + 120)*
- *Maximum creel size : 600*

No. of ends to be taken in first section	: 520+60 = 580
Section width - First section	: 122.76 mm (4.83")
No. of ends in sections 2 to 12	: 520
Section width for section 2 to 12	: 110.07 mm (4.33")
No. of ends in section 13 (last section)	: 360+60 = 420
Section width – Last section	: 88.9 mm (3.5")

The value of 110.07 can be located in table 4.3 under 120 EPI column. The section width for first and the last sections will be adjusted by rotating main flanges outside or inside.

Example 2:

Following are the details of the warp yarn to be processed.

- *Ends per inch : 80*
- *Width : 1600.2 mm (63 inches) including selvedges*
- *Selvedge : 80 ends per inch, 0.5" on each side, white color*
- *Warp pattern repeat : 28 ends, 3 colors*
- *Total ends : 5040 (4960 + 80)*
- *Maximum creel size : 600*

No. of ends to be taken in first section : 560+40 = 600

Section width - First section : 190.5 mm (7.5")

No. of ends in sections 2 to 7 : 560

Section width for section 2 to 7 : 177.8 mm (7.0")

No. of ends in section 8 (last section) : 480+40 = 520

Section width – Last section : 115.1 mm (6.5")

The value of 177.8 can be worked out from table 4.5 against 80 EPI. The table does not have values for the required section width but the same can be selected as an initial condition. This will be set by rotating the inner barrel by a fraction of the full revolution. The values for maximum number of ends for a given section width have been derived by considering full rotation of the inner barrel which will give integer value of the section width in an increment of 1 mm. So any other value will require a fractional rotation of the inner barrel. This is quite possible in the proposed design.

The section width for first and the last sections will be adjusted by rotating main flanges outside or inside.

4.3.3 Measurements for Third Attempt

In third attempt, the inner barrel has been designed to have the teeth with continuously increasing pitch. The pitch selected currently is from 10 mm to 20 mm over a toothed portion of 1600 mm. Also as mentioned earlier, the inner fixed flange has been included in the design. So the width for first section will be adjusted by rotating main flange of the left hand side of the beam when looking at it from the beaming side. For remaining sections, except the second last, the width will be adjusted by moving separator plates. The first plate is to be mounted at a point where the toothed portion of inner barrel starts i.e. at a pitch value of 10 mm. Remaining number of separator plates need to be calculated as per requirement of a particular situation. Also the location of all remaining separator plates need to be worked out.

Second important aspect will be the initial distance kept between the inner fixed flange and first separator plate. As the position of inner fixed flange is not required to be adjusted, this distance can be worked out for a particular situation and a suitable value can be set up as an initial condition.

Table 4.8 shows maximum number of ends which can be taken for various values of ends per inch starting from 40 EPI to 140 EPI in a group of 10 value. Another variable is the initial distance set between the inner fixed flange to first separator plate. If we place the first separator plate at starting point (at 10 mm pitch value) and keep the distance between the inner fixed flange and the plate as 100 mm, the first raw will show the maximum ends. Similarly by shifting the first separator plate by every rotation, the distance from the inner fixed flange increases and values of maximum ends will reflect in various raw.

Similar tables can be worked out by varying the initial distance kept between inner fixed flange and first separator plate depending upon the requirements. This will give different number of maximum ends which can be taken for a situation. This means that it is possible to use the design for the purpose.

		Ends per Inch										
		40	50	60	70	80	90	100	110	120	130	140
Initial Section Width (mm)	**Pitch Value for First Plate (mm)**											
100.0	10.0	157	197	236	276	315	354	394	433	472	512	551
110.1	10.1	173	217	260	303	347	390	433	477	520	564	607
120.3	10.2	189	237	284	332	379	426	474	521	568	616	663
130.6	10.3	206	257	309	360	411	463	514	566	617	668	720
141.0	10.4	222	278	333	389	444	500	555	611	666	722	777
151.5	10.5	239	298	358	418	477	537	596	656	716	775	835
162.1	10.6	255	319	383	447	511	574	638	702	766	830	893
172.8	10.7	272	340	408	476	544	612	680	748	816	884	952
183.6	10.8	289	361	434	506	578	651	723	795	867	940	1012
194.5	10.9	306	383	459	536	613	689	766	842	919	995	1072
205.5	11.0	324	405	485	566	647	728	809	890	971	1052	1133
216.6	11.1	341	426	512	597	682	767	853	938	1023	1109	1194
227.8	11.2	359	448	538	628	717	807	897	987	1076	1166	1256
239.1	11.3	377	471	565	659	753	847	941	1035	1130	1224	1318
250.5	11.4	394	493	592	690	789	888	986	1085	1183	1282	1381
262.0	11.5	413	516	619	722	825	928	1031	1135	1238	1341	1444
273.6	11.6	431	539	646	754	862	969	1077	1185	1293	1400	1508
285.3	11.7	449	562	674	786	899	1011	1123	1236	1348	1460	1573
297.1	11.8	468	585	702	819	936	1053	1170	1287	1404	1521	1638
309.0	11.9	487	608	730	852	973	1095	1217	1338	1460	1581	1703

Table 4.8 Number of maximum ends with section width of 100 to 309 mm

4.3.4 Calculations for Third Attempt

Considering the examples used for the second attempt with the data provided at section 4.3.2 for the second attempt, following settings will emerge. The section width for first and the last sections in both examples will be set by rotating the main flanges of both sides. This is possible because of introduction of inner fixed flange. For example 1, the section width required for sections 2 to 12 is 110.07 mm. For example 2, the section width required for sections 2 to 7 is 177.8. Both values can be located in table 4.8 by taking suitable data of respective example.